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FUSION MICROSPHERE TARGETS

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FUSION MICROSPHERE TARGETS*

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ABSTRACT

We showed that a microsphere within the structure limitations is hydrodynamically stable. To insure its perfect formation, the initial chemical compositions must have a blowing capability, more important, the resultant liquid compositions must also have sufficient surface tension and low viscosity.

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Hollow microspheres, within the structural limitations, are stable even in their liquid state. This basic physical concept is first verified by using a static model where each of the two surfaces (both inside and outside surfaces) is assumed to be spherical.[1] Because of the stress caused by surface tension, the two surfaces are forced to be concentric. The dimensions of the microspheres are limited due to the instability caused by gravity. Within the limitations, microspheres are hydrodynamically stable and the effect of a gravitational field can be neglected.

The dynamic Rayleigh-Taylor instability calculation[2] of the hydrodynamic stability of microspheres removes the necessity of assuming spherical surfaces. It shows that the Rayleigh-Taylor instability of microspheres is damped by surface tension. There exist limitations within which microspheres are hydrodynamically stable.

Microspheres required for fusion targets are, so far, within the limitations of the hydrodynamic stability. They can be produced systematically and consistently. The basic and the most important requirement for the formation of a perfect microsphere is that it should be allowed to stay in the liquid fusion state long enough for its center bubble to be able to reach its balance state - the concentric position. This characteristic time is determined by its own centripetal force caused by its surface tension and by the viscosity of the liquid.

To form a hollow microsphere, it is quite obvious that one needs to entrap some gases in a shell. Besides direct air blowing, these gases can be generated from the composition directly. Even though this trapping can be different in different production, the basic aspects are similar. In all cases gases have to be present as the chemicals are fusing.

Besides trapping air, the two surfaces of a perfect microsphere will have to be made concentric. This can be done under its own internal forces provided there exists enough time (limited only by the gas permeation process) to complete the motions. Since glass viscosity is exponentially dependent upon temperature, the period that it spends in the high temperature fusion oven is important. This period of time, because of the more or less constant terminal velocity of the microsphere, is directly proportional to the length of the oven. Generally this is limited, so is the temperature of the oven. To insure high quality glass microspheres, one has to choose a composition so that, at the high temperature, the viscosity is a minimum for all possible combinations. This is accomplished in the low Z glass cases by choosing the chemical compositions at, or near, the eutectic points, such as the high sodium glass composition used in the "Droplet Generator Method,"[3] and the high potassium glass composition (JK α series) in the "Dry Gel technique."[4] It should be made clear that we are not trying to form low temperature glasses but glasses with low viscosities. No stabilizing agent is added in the bulk because of their effect of increasing the viscosity. These glass microspheres are stabilized only by surface treatment: aluminum deposition through C.V.D. and a chemical leaching process.[5] The same principles are required in the case of high lead oxide glasses,[6] as another example of semi-direct production process. In the flux method,[7] which we have successfully developed, these principles are still observed indirectly in the production of those more difficult microspheres.

Here, we point out the basic requirements for the chemical composition in the formation of microspheres. These requirements are consistent with our physical analysis and can be accomplished by careful choice of the chemicals.

REFERENCES

1) J. C. Koo, "Concentricity of Micropellets," Lawrence Livermore Laboratory Report UCRL-81839 (1978).

2) S. Chandrasekhar, "Hydrodynamic and Hydromagnetic Stability," Oxford University Press, 1961.

3) A. Rosencwaig et al, "Laser Fusion Hollow Glass Microspheres by the Liquid-Droplet Method," Lawrence Livermore Laboratory Report UCRL-81421 (1978).

4) C. D. Hendricks et al, "Fabrication of Glass Sphere Laser Fusion Targets," Lawrence Livermore Laboratory Report UCRL-81415 (1979).

5) A Rosencwaig et al, "Surface Treatment of LLL Glass Miscospheres," Lawrence Livermore Laboratory Report UCRL-81436 (1978).

6) J. C. Koo, "Lead Glass Microspheres," Lawrence Livermore Laboratory UCRL-83400 (1979).

7) J. C. Koo, "The Flux Method for Fusion Microsphere Targets," Lawrence Livermore Laboratory UCRL-83397 (1979).